

What is Claimed is:

1 1. A plug tool for forming internally helically ribbed tube, comprising
2 a plug including a plug body for being rotatably disposed in a die orifice of
3 a drawing die and having a central longitudinal axis, a plurality of external
4 grooves equally spaced about said central longitudinal axis, and a plurality of
5 external lands in alternating arrangement with said grooves, said grooves
6 extending longitudinally along said plug body at a helix angle to said central
7 longitudinal axis and closely corresponding to internal helical ribs formed in
8 tubing drawn in a forward direction through the drawing die with said plug body
9 disposed within the tubing, each of said grooves having a cross-section normal to
10 said groove defined by a root surface and a pair of flank surfaces extending
11 angularly outwardly away from one another from said root surface to land
12 surfaces of adjacent ones of said lands, said flank surfaces extending angularly
13 outwardly from said root surface at different angles.

1 2. The plug tool recited in claim 1 wherein said helix angle is 40°, a
2 rearward one of said flank surfaces of each of said grooves defines a radial angle
3 of 37°, and a forward one of said flank surfaces of each of said grooves defines
4 a radial angle of 16°.

1 3. The plug tool recited in claim 2 wherein said grooves have a width
2 and said land surfaces have a width at least substantially the same as said width
3 of said grooves.

1 4. The plug tool recited in claim 1 wherein said plug body comprises
2 an intermediate length section disposed between a forward length section and a

3 rearward length section, said intermediate length section defining an external
4 cylindrical configuration, said forward length section being externally chamfered
5 from said intermediate length section to a forward end of said plug body, said
6 rearward length section being externally tapered from said intermediate length
7 section to a rearward end of said plug body.

1 5. The plug tool recited in claim 4 wherein said rearward length
2 section is externally tapered at an angle of about 7° to an outer diameter of said
3 intermediate length section.

1 6. The plug tool recited in claim 4 wherein said external grooves and
2 said external lands have forward ends, respectively, on said forward length
3 section and rearward ends, respectively, on said rearward length section.

1 7. The plug tool recited in claim 1 wherein said plug body comprises
2 four or more of said external grooves and a number of said external lands equal
3 to the number of said external grooves.

1 8. The plug tool recited in claim 1 wherein said plug body is integral
2 and unitary with a connector comprising an externally threaded extension
3 extending coaxially from said plug body in a rearward direction for threaded
4 connection in a passage in a forward end of a shaft received in the tubing drawn
5 through the drawing die.

1 9. The plug tool recited in claim 1 wherein said plug body includes a
2 bore extending longitudinally therethrough coaxial with said central longitudinal
3 axis.

1 10. The plug tool recited in claim 9 and further comprising a connector
2 having a head disposed at an end of a shank, said shank having a cylindrical
3 length portion extending rearwardly from said head and a threaded length portion
4 extending rearwardly from said cylindrical length portion, said shank being
5 insertable in said bore with said head disposed externally of said plug adjacent a
6 forward end of said plug body, said cylindrical length portion disposed in said
7 bore, and with said threaded length portion extending rearwardly from said plug
8 body for threaded connection in a passage in a forward end of a shaft received in
9 the tubing drawn through the drawing die.

1 11. A plug tool for forming internally helically ribbed tube, comprising
2 a plug including a plug body for being rotatably disposed in a die orifice of
3 a drawing die and having a central longitudinal axis, a plurality of external
4 grooves equally spaced about said central longitudinal axis, and a plurality of
5 external lands in alternating arrangement with said grooves, said grooves
6 extending longitudinally along said plug body at a helix angle to said central
7 longitudinal axis and corresponding to internal helical ribs formed in tubing drawn
8 in a forward direction through the drawing die with said plug body disposed within
9 the tubing, each of said grooves having a cross-section normal to said groove
10 defined by a root surface and a pair of flank surfaces extending angularly
11 outwardly away from one another from said root surface to land surfaces of
12 adjacent ones of said lands, said root surface having a width in said cross-
13 section defined between first and second radii, a rearward one of said flank
14 surfaces being disposed at a first angle to said first radii and a forward one of
15 said flank surfaces being disposed at a second angle, smaller than said first
16 angle, to said second radii.

1 12. The plug tool recited in claim 11 wherein said helix angle is 40°,

2 said first angle is 37° and said second angle is 16° .

1 13. The plug tool recited in claim 11 wherein each of said land surfaces
2 has a width and said width of said land surfaces is at least substantially the same
3 as said width of said root surfaces.

1 14. The plug tool recited in claim 13 wherein said width of said root
2 surfaces is in the range of about 3.9mm to about 4.3mm.

1 15. The plug tool recited in claim 14 wherein said grooves have a depth
2 and said depth of said grooves is in the range of about 1.3mm to about 1.6mm.

1 16. The plug tool recited in claim 11 wherein said plug body is made of
2 tool steel hardened and triple tempered to about 63RC.

1 17. The plug tool recited in claim 16 and further comprising a
2 deposition of titanium nitride on said plug.

1 18. The plug tool recited in claim 16 and further comprising a coating of
2 mono-molecular diamond on said plug.

1 19. The plug tool recited in claim 16 and further comprising a coating of
2 titanium nickel carbide on said plug.

1 20. A plug tool for forming internally helically ribbed tube, comprising
2 a plug including a plug body for being rotatably disposed in a die orifice of
3 a drawing die and having a central longitudinal axis, a plurality of external

4 grooves equally spaced about said central longitudinal axis, and a plurality of
5 external lands in alternating arrangement with said grooves, said grooves
6 extending longitudinally along said plug body at a helix angle to said central
7 longitudinal axis and corresponding to internal helical ribs formed in tubing drawn
8 in a forward direction through the drawing die with said plug body disposed within
9 the tubing, each of said grooves having an asymmetrical cross-section normal to
10 said groove defined by a root surface, a rearward flank surface extending
11 angularly outwardly from said root surface at a first radial angle and a forward
12 flank surface extending angularly outwardly from said root surface at a second
13 radial angle, less than said first radial angle, and in a direction opposite said
14 rearward flank surface;

15 an elongate shaft for being received in the tubing drawn through the
16 drawing die and having a forward end for being coupled to said plug body; and
17 a connector for coupling said plug body to said forward end of said shaft
18 for rotation of said shaft as one with said plug body when said plug body rotates
19 in the die orifice about said central longitudinal axis.

1 21. The plug tool recited in claim 20 wherein said shaft comprises an
2 axial threaded passage therein at said forward end and said connector
3 comprises an externally threaded extension extending coaxially from a rearward
4 end of said plug body for threaded engagement in said passage.

1 22. The plug tool recited in claim 21 wherein said extension is integral
2 and unitary with said plug body.

1 23. The plug tool recited in claim 21 wherein said plug body has an
2 axial bore extending entirely therethrough and said connector comprises a head

3 and a shank extending from said head, said shank having an externally threaded
4 portion, said shank being insertable in said bore with said externally threaded
5 portion extended coaxially from said rearward end of said plug body to define
6 said extension.

1 24. The plug tool recited in claim 23 wherein said head defines a
2 forward abutment at a forward end of said plug body and said forward end of said
3 shaft defines a rearward abutment at said rearward end of said plug body and
4 said plug body is confined in the axial direction between said forward and
5 rearward abutments.

1 25. The plug tool recited in claim 23 wherein said connector comprises
2 a socket head cap screw.

1 26. The plug tool recited in claim 20 wherein said shaft comprises a
2 back-bar having a forward end defining said forward end of said shaft.

1 27. The plug tool recited in claim 20 wherein said shaft comprises a
2 back-bar and an adapter connected to said back-bar, said adapter having a
3 forward end defining said forward end of said shaft.

1 28. The plug tool recited in claim 27 wherein said back-bar has an
2 outer diameter to fit within the tubing and said adapter has an outer diameter to
3 fit more closely within the tubing than said outer diameter of said back-bar.

1 29. The plug tool recited in claim 20 and further comprising a guide
2 tube receiving said elongate shaft, said guide tube having an inner diameter to

3 accommodate the tubing in which said shaft is disposed.

1 30. A plug tool for forming internally helically ribbed tube, comprising
2 a plug including a plug body for being rotatably disposed in a die orifice of
3 a drawing die and having a central longitudinal axis, a plurality of external
4 grooves equally spaced about said central longitudinal axis, and a plurality of
5 external lands in alternating arrangement with said grooves, said grooves
6 extending longitudinally along said plug body at a helix angle to said central
7 longitudinal axis and closely corresponding to internal helical ribs formed in
8 tubing being drawn in a forward direction through the drawing die with said plug
9 body disposed within the tubing, each of said grooves having an asymmetrical
10 cross-section normal to said groove defined by a root surface and a pair of flank
11 surfaces extending from said root surface to land surfaces of adjacent ones of
12 said lands, each of said grooves having a width at said root surface and between
13 said flank surfaces, each of said lands having a width substantially equal to said
14 width of said grooves.

1 31. The plug tool recited in claim 30 wherein said width of each of said
2 grooves is defined between radii of said central longitudinal axis.

1 32. The plug tool recited in claim 31 wherein each of said grooves has
2 a rearward one of said flank surfaces defining an angle of 37° with one of said
3 radii and a forward one of said flank surfaces defining an angle of 16° with the
4 other of said radii.

1 33. A method of producing internally ribbed tube, comprising the steps
2 of

3 drawing a length of plain tubing longitudinally in a forward direction over a
4 plug body rotatably disposed in a die orifice of a drawing die and having a
5 plurality of external grooves at equally spaced locations about a central
6 longitudinal axis of the plug body and extending longitudinally at a helix angle to
7 the central longitudinal axis in alternating arrangement with a like plurality of
8 external lands, wherein each groove has a root surface and a pair of forward and
9 rearward flank surfaces extending from the root surface at different radial angles
10 in opposite directions from one another to the land surfaces of a pair of adjacent
11 ones of the lands, wherein the radial angle of the forward flank surfaces is less
12 than the radial angle of the rearward flank surfaces; and
13 constricting the tubing in the drawing die to force an internal surface of the
14 tubing into the external grooves of the plug body to form a plurality of continuous
15 helical ribs extending longitudinally along the internal surface in correspondence
16 to the external grooves.

1 34. The method recited in claim 33 wherein said step of drawing is a
2 second drawing step and further including, prior to said second drawing step, the
3 steps of drawing the tubing over a plain plug in a first drawing step and annealing
4 the tubing subsequent to said first drawing step and prior to said second drawing
5 step.

1 35. The method recited in claim 34 and further comprising, subsequent
2 to said second drawing step, the steps of heat treating the tubing, straightening
3 the tubing and cutting the tubing into tubes of desired length.

1 36. The method recited in claim 35 and further including the steps of
2 subjecting the tubing to wet preparation prior to said first drawing step and

3 subsequent to said first drawing step and prior to said second drawing step, and
4 removing points and tails from the tubing subsequent to said second drawing
5 step and prior to said heat treating step.

1 37. The method recited in claim 36 and further including, subsequent to
2 said step of cutting, the steps of applying corrosion protection to the tubes,
3 capping the ends of the tubes, bundling the tubes, documenting the tubes,
4 labeling the tubes, storing the tubes and shipping the tubes to a designated site.

1 38. The method recited in claim 36 wherein said step of subjecting the
2 tubing to wet preparation includes the steps of chemically descaling the tubing,
3 passivating the surface of the tubing, soaping the tubing and drying the tubing.

1 39. The method recited in claim 38 wherein said step of chemically
2 descaling comprises applying a sulphuric acid solution to the tubing.

1 40. The method recited in claim 38 wherein said step of passivating
2 comprises applying a phosphate solution to the tubing.